Title : A Brief History of System Additions & Material Innovation in the Light Frame House

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Abstract

The contemporary house has over 54 thousand parts (approx. 3,896 parts plus 50,650 fasteners in a 30x40 2 story gable roofed house) and 30 systems installed by 17 subcontractors, each seeking to optimize the installation of their system. In recent years the homebuilding industry has seen dramatic failures of innovative materials, proven commercial materials failing at the interface with traditional homebuilding systems and failures of proven materials at the interface with energy conserving materials. When did homebuilding get so complicated? At what point did a square, a saw, a hammer, and some know-how become insufficient to build a house? This paper traces the development of the light frame house from its introduction in Chicago in the 1830's (with apologies to Cavanagh[1]) to its current version, noting the incremental additions of systems, materials, and expectations (and unanticipated results)which substantially comprise the house of 1998.

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The "house" of 1998 is a complex assemblage of systems, components, elelments, and materials. There are easily over 54 thousand parts assembled on the construction site to make the house. These parts are acquired from over 400 manufacturers, and are assembled by approx. 17 subcontractors, who are pressured by workload, slim profit margins, and high personnel and capital equipment costs to conduct their work as quickly and efficiently as possible, in order to proceed to the next project. (Table 2) This and a lack of full coordination between systems, manufactured materials, and subcontracts, often places the first subcontractor on site in the most advantageous position of not having to cope with or compensate for the work of a previous subcontractor. All following subcontractors are put in the position of adjusting, revising, avoiding, or removing the work of previous subcontractors in order to meet the timeframes imposed on them by the economics of the housing market.

But how did we get to this point? How did Adams' house in paradise get this complicated?[2] Did Adam have problems with punch list completion? The brief history of the light frame house which follows shows the incremental addition of expectations, systems, and dissimilar materials over the one hundred sixty years since its birth.

With the patenting of the nail making machine in 1795 by Jacob Perkins the revolution in housing had begun. In 1795 nails cost the astronomical sum of 25 cents a pound. [3] This high price kept the "fastener free" - joinery intensive heavy timber frame and masonry construction as the dominant method in the housing construction industry.

In 1832 George Snow introduced balloon framing to the building industry in Chicago. This way of building allowed a man and a boy to erect the frame in a relatively short period of time using simple tools, minimal joint preparation and was tolerant of inexperienced carpenters.[4] The change from timber and braced framing to the balloon frame reduced the amount of materials, reduced the number of craftsman needed to construct the frame, and reduced the amount of time needed to erect the frame for a house. At that time, the frame had few responsibilities beyond structure. It had to accept siding to keep rain out, plaster or interior wood panels to finish the space but the plumbing was outside the house at the well or cistern, the sewage was outside the house at out house, and the only heat came from the fireplace. Windows were small, made of small panes of glass, single glazed and fairly expensive.

By 1869 nail costs had fallen below 5 cents a pound, the Civil War had ended and a construction boom was following the homesteaders into the opened Western territories. The balloon frame was the construction method of choice for the fast developing towns of the West. Framing lumber from the Great Lakes region was being shipped along the fast developing railroads and transformed into commercial and residential structures with a speed not possible with joinery-dependent timber frames or masonry construction. (Figure 1)

The frame was largely the same as that demonstrated by George Snow in 1832, but now had the responsibility to accommodate gaspipe for lighting, and plumbing. The water closet moved in from the backyard out house to a shed which was attached to the house but was accessed only from the outside. Lead pipe formed the conduits accommodating plumbing from the kitchen range / boiler to the now attached laundry shed, plumbing from the cistern to the kitchen pump, from the kitchen sink, laundry tubs, and from the upstairs "tub room" to the cesspool. (Figure 2) The fireplace was a standard house element, but the coal fired furnace began to make its appearance, heating water for radiators throughout the house. Electrical systems in the form of zinc tube conduits for the doorbell circuit began to appear.[5] Interior walls and ceilings were plastered, with extensive use of wallpapers to conceal surface irregularities and temperature induced cracking.

By 1880, Edison's practical interior lamp and Bell's telephone had been widely demonstrated and were rapidly moving toward mass adoption. The Victorian house was becoming a refined environment, and partly as a reaction to it's perceived feminine qualities the Craftsman house appeared on the scene. Gustav Stickley, architect, furniture maker and interior designer, began publication of "The Craftsman" a periodical promoting simple (and more masculine) values.. and a line of furniture, light fixtures, and heating accessories. The Craftsman home also promoted a change in floor plan strategy from a series of discrete rooms to what Stickley called a “Great Room” and included screened sleeping porches. The Craftsman houses were mostly balloon framed two story designs and bungalows. Perhaps in response to the great fires in Chicago, Boston, and San Francisco, many of the designs featured cement / stucco exterior siding backed up with “vitrified terra cotta” between the studs. Like the Victorian house, hardwood floors were the norm, but now the plaster was limited to a frieze above interior wood paneling and between the exposed ceiling beams. The simple wood frame now accommodated full drain, waste, and vent systems. Lead water supply piping connected the kitchen sink pump with the well, and water heating for bathing and laundry was still piped from the kitchen range. The kitchen icebox was often located on the back porch, but moved into the kitchen in designs from 1912. The icebox was “iced” through and exterior door in it’s back, keeping ice deliveries out of the kitchen proper. The fireplace chimney also accepted flues for the coal fired furnace / radiant heating system. As an option to the usual cedar shingle roof, a roll roofing product called “rubberoid roofing” was available and the attached garage made its appearance.[6] (Figure 3)

In 1919 the Ray Bennett Lumber Co. began marketing a line of house kits. These houses used the platform frame in lieu of the balloon frame. Tarred paper was specified under the siding. Electric power distribution in addition to electric lighting was standard practice. The exterior walls still did not have any insulation product installed in the stud cavity. Local improvisations included back plastering the exterior wall, filling the cavity with newspapers and even ash from the fireplace[7] were observed in cold climates. The standard floors were yellow pine, with oak available as an additional cost. The fireplace became optional, with the coal fired hot water furnace in wide use. The ductless hot air furnace was almost as popular (Figure 4), and the new ducted hot air furnace was just arriving on the scene. Even though home refrigeration was available since 1918, most of the designs showed places on the back porch for ice storage. Indoor plumbing had progressed from a minimal installation (1 tub, w.c., lav, and sink) to two full baths. Sewage systems developed to a “two tank” septic disposal system (Figure 5) and lead pipe was replaced with galvanized steel. The water heater was now a separate appliance, fired by kerosene. Most houses had telephone wiring and all houseplans had available separate garage plans.[8]

The 1922 Pre-Cut house, by the Gordon-Van Tine company reduced construction time for the exterior frame to an astonishing 14 days after the foundation was completed. All plates in these platform frame designs were notched to receive studs, all rafters were precut, as were door and window frames, floor and ceiling joists. (Figure 6) Insulation was not yet part of the construction but owners in Northern climates were advised “If you live in the extreme Northern part of the country you may want to back plaster and put building paper under the roof shingles for warmth.) Red Rosin building paper was specified under the siding as well as around all windows and door openings, a recognition of durability / rot issues. Another recognition of the thermal performance of the home designs was the appearance of an entrance vestibule in most plans. The attic became an integral space in the house with the installation of disappearing stairs. Asphalt roof shingles, rolled roofing, and cedar shingles are all part of the standard product line. Lead based paints were common across construction at this time. “Plaster board” began to take its place in the market, reducing the costs associated with plastering. Galvanized steel water piping, pressurized water systems, and ducted furnaces were all part of these complete home kits.[9]

Pre-cut houses were a popular method of decreasing cutting waste, decreasing construction time and insuring material quality. Taken together, these aspects almost assured the home buyer of a quality level which would assure durability and increasing value. The next logical step for the precut producers (Sears, Acorn, Gordon-Van Tine, Bennett) was to provide construction services to their buyers. This first trend towards a regional (sometimes national) construction company was cut short by the 1929 depression which forced even the commercial giant, Sears out of the home-building business by 1933.

The sluggish economy in the late 30’s provided little incentive for home construction or significant innovation on a large scale. One of the notable innovations in home building was offered by architect Frank Lloyd Wright through a series of home designs he titled “Usonian Houses.” The first Usonian House was built for Herbert Jacobs in Madison Wisconsin during 1937. The house was touted by Wright through the popular press as “the $5,000.00 house.” Usonian houses were the first complete re-think of the wood house since its inception in the 1830’s. Wright eliminated the attic and basement as unnecessary volumes consuming precious heat. He imported flat roof technology from the commercial market as the most cost effective way to roof, and included clerestory windows to aid in daylighting, and naturally ventilating the space below. Wright re-thought the process of building the house, constructing the slab-on-grade first (with integral hot water radiant heating) a few masonry elements which laterally stabilize the structure, and before building the walls, the roof was erected. The space below the roof, atop the slab, became the contractors workshop. In this space all the lumber for the walls, cabinets, and built in furniture was milled shaped, and wall units pre-assembled for later erection. The walls themselves having been freed from load bearing by masonry elements and columns integrated into door / window openings, had no studs in them. Walls were constructed with layer of horizontal shiplap cypress siding on the exterior, a layer of building paper, a layer of “Z-Ro-Board” (softwood plywood) and on the inside, a layer of shiplap cypress identical to the exterior siding. The houses were carefully sited to take maximum advantage of the sun and prevailing breezes. Overhangs were designed to provide summer shading, but allow winter sun penetration. The Usonian type called the “hemicycle” incorporated two story sunspaces, earth berming to provide additional insulation to the north side, and functional zoning allowing occupants live in a warm zone in winter and cool zone in summer.[10]

The post World War II housing industry saw innovations such as the Dymaxion home, a lightweight aluminum construction, the “Lustron” home, a porcelain enameled steel panel and metal stud construction, the mobile home and other industrialized home packages attempting to use surplus manufacturing production facilities to address the need for housing for returning veterans. The platform framed wood house continued to dominate construction methods. Fiberglass and “Rockwool” insulation were common in walls and attic spaces. Asbestos reinforced shingles, plaster, and siding were common. Low - slope built up roofs made their appearance in the southwest U.S. By the late 1950’s plywood (first introduced in the 1890’s in the furniture industry) began to replace diagonal wood subfloors, aluminum and steel siding made their appearance on the market, as preventative home maintenance came to be questioned by the labor-saving-device oriented generation. The 1960’s saw the continued penetration of plywood into the system, as diagonal wood wall and roof sheathing disappeared. The ability to treat plywood to resist combustion allowed wood framing to be used for larger and taller commercial / multifamily housing projects. Inexpensive oil prices and the promise of nuclear energy generation kept energy from becoming an issue. Labor prices increased at a faster rate than materials and adhesives and power nailers entered the jobsite, Thermal concerns had not developed since the post-war boom began and the only innovation in the thermal envelope was the introduction of foam plastics. The advent of affordable television added antennae wiring to the infrastructure of the house.

The early 1970’s brought the oil embargo, resulting shortages in heating oil, and increase in energy prices across the board. The natural gas industry made significant gains as a home energy source marketing availability, stable costs, and clean burning, a factor noted by the beginning environmental movement. The energy crisis produced significant changes in the thermal expectations for homes. Government programs encouraged (through tax incentives) application of solar technology, increased insulation, and weather-stripping for openings. Fireplace and furnace technology improved by adding a separate duct for providing combustion air to the fireboxes, limiting the amount of air pulled through windows, doors, and cracks. Labor prices continued to climb, contributing to the wide adoption of the plate truss for roof structures. Particle board began to replace plywood in cabinets and as underlayment. During the middle and late 70’s the effects of energy efficient construction became a concern as occupants of these homes noticed increased incidents of allergic reaction, and upper respiratory system infections. Studies pointed to a number of factors contributing to the problems, decreased air infiltration, chemicals present in the adhesives used in particle boards, furniture, paints, and adhesives generally used for floor coverings. Grouped under the title of indoor air quality, recommendations to industry, applicators, constructors and owners caused the reformulation of adhesives and paints, the development of separate ventilation and heat recovery systems (more ductwork) and extensive studies of the effects of natural pollutants on the indoor air environment began.

By the 1980’s, environmental concerns began to grow in influence and impact political campaigns, finding a place on the national legislative agenda. Lead mitigation, and asbestos abatement were common projects for the renovation industry. A further impact of environmental consciousness was the effort to protect the remaining stands of first growth timber in the Northwest. Plate trusses for floor construction became common during this time and oriented strand board was making its way into the market, replacing plywood for wall, roof, and floor sheathing. Standard practices for the thermal performance included continuous vapor barriers, R19 walls, R30 floors and roofs, and 1/2 inch insulating glass in all windows. The first delamination failures of hardboard siding and fire retardent treated plywood were occurring. Oriented strand board based sidings began to make their appearance as did the transfer of exterior finish and insulation systems from commercial to residential projects. Home theater systems showed up in “move up” houses. Multiple telephones were common in housing, and cable TV replaced antennae wiring in most houses. Rising crime rates made intrusion / detection systems and their associated wiring and devices common in many urban and suburban construction projects.

The 1990’s saw the entry of “I” joist products into the housing market as floor and roof joists, and today as wall studs. The “connected generation” also demanded additional wiring for home phones, fax machines, and home computer networks began enter the market. Intelligent lighting control devices scanned spaces for thermal and motion activity saving energy by turning lights on and off as needed. Vinyl siding dominated the market with vinyl, vinyl clad wood, and metal windows as homeowners sought to eliminate exterior maintenance. Radon detection and mitigation became common in many parts of the country as the USGS identified counties at risk for radon exposure. Major hurricanes in the Southeast and earthquakes in the west renewed interest in the structural performance of the house as a whole. Failures of oriented strand based siding products, and exterior insulation and finish systems reminded the industry of the interactions between materials / systems. The government succeeded to move advanced materials and methods to the housing industry through the “Build America” program. Based on that success, the PATH was formed to continue advocating the adoption of new materials and methods in an effort to improve affordability, decrease CO2 emissions, reduce energy consumption, and insure the continuation of the house as a primary wealth building tool for it’s citizens into the next century.

From the simplicity of the 1830’s house with only a structure / enclosure system, simple enough to be constructed by a man and a boy[11], our house in 1998 now carries an additional12 systems, and instead of being constructed by a man and a boy, some 17 subcontractors are the constructors. (Table 1)The central problem to be investigated from this point is where each system is installed in each house, and what each system can do to bring the whole to a higher level of performance in terms of durability, energy consumption, and wealth building. The task is not unlike the accomplishments of the aerospace industry, which in the forty years between the introduction of the Boeing 707 and 777 improved performance (dollars per passenger mile) by over 200%, with no substantial change in materials, methods, or form. The careful design of each system in terms of the performance of the whole should be able to make substantial improvements in energy, indoor air quality and durability while reducing the fossil fuel load (and resulting CO2 emissions) placed by the house on the environment.

Table 1 Systems in Housing

	1998 version:	1830's version
1.	below grade waterproofing	not present
2.	footing/foundation	present
3.	superstructure	present
4.	insulation	not present
5.	wind barrier	not present
6.	vapor barrier	not present
7.	finishes	present
8.	roofing	present
9.	water supply	not present
10.	drain	not present
11.	plumbing ventilation	not present
12.	vapor exhaust	not present
13.	radon exhaust	not present
14.	electric power	not present
15.	electric light	not present
16.	intrusion detection	not present
17.	telephone	not present
18.	data network	not present
19.	home theater	not present
20.	heat	fireplace
21.	gas	not present
22.	air conditioning	not present
23.	humidification	not present
24.	filtration	not present
25.	storage	not present
26.	sun control	not present
27.	lighting contorls	not present
28.	irrigation	not present
29.	water conditioning	not present
30.	cable tv	not present

Table 2 Subcontractors in Housing

1. excavator
2. concrete finisher
3. mason
4. waterproofing
5. insulation
6. rough framing
7. drywall
8. electrical subcontractor
9. plumber
10. hvac subcontractor
11. painter
12. tile setter
13. carpet installer
14. finish carpenter
15. roofing subcontractor
16. gutter & downspout
17. irrigation subcontractor

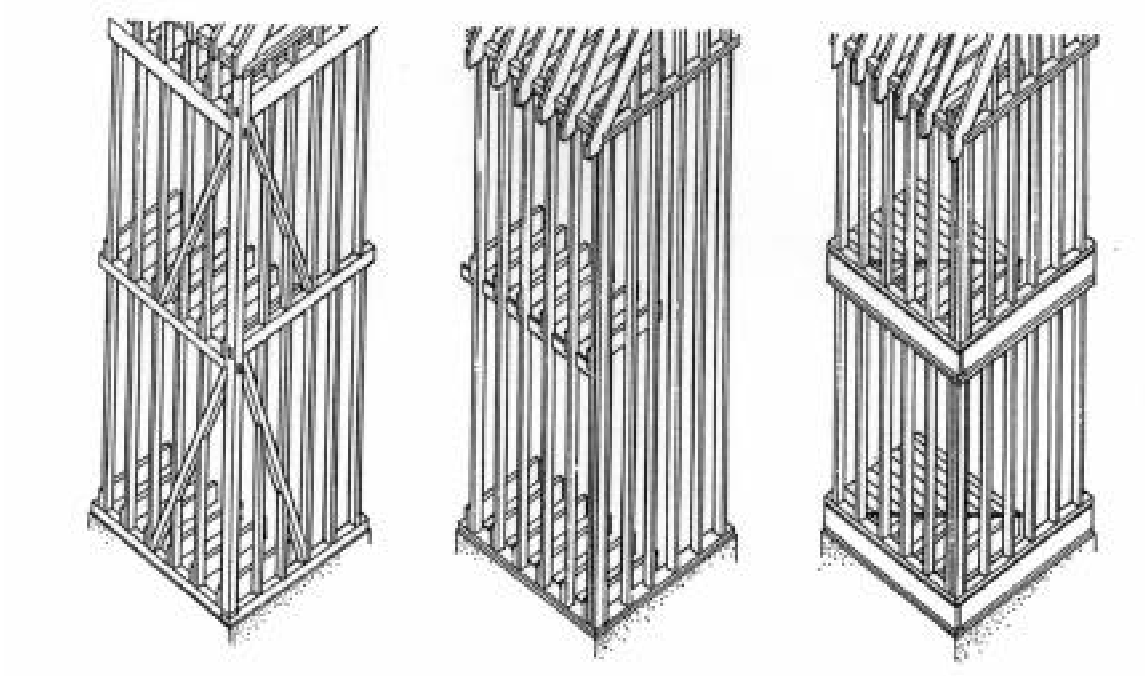


Figure 1. Framing Diagrams: From Left to Right, Box (Braced) Frame, Balloon Frame, Platform Frame (source; Elliott, Technics in Architecture, used with the permission of the author and MIT press)

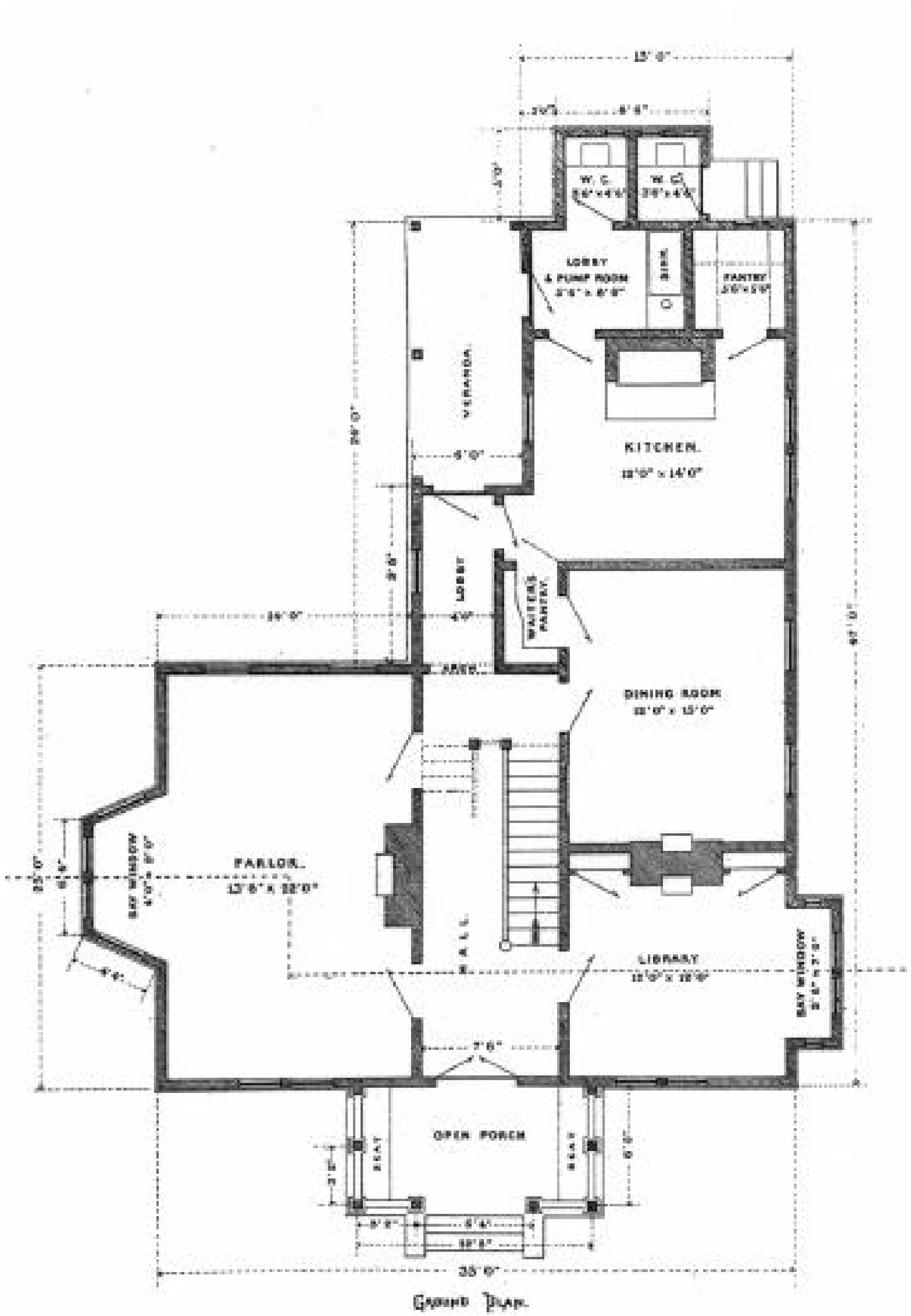
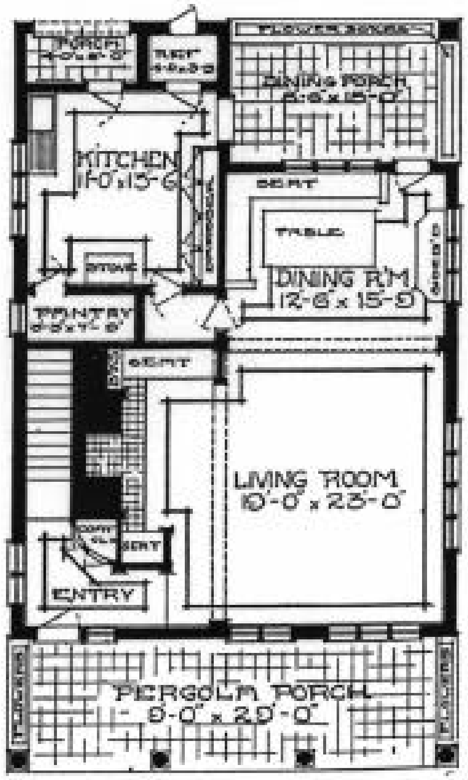


Figure 2. House Plan: 1869 (source; Woodward)



COTTAGE NO. 112: FIRST FLOOR PLAN.

Figure 3. 1911 Cottage (source; Stickley)

Van Tine Pipeless Furnace

Will Keep Your Home at 70°

FOR a small home when all things are considered, no system of heating can compare with the Van Tine Pipeless System, and especially is this true when the element of first cost is considered. This heating has stood the test of time and is today more popular than ever before.

The Van Tine one-register furnace is as easy to operate as a stove. No coal to carry upstairs, no ashes to carry down, just one fire in your cellar alongside your coal pile and one draft regulator in the living room. The Van Tine one-register heater can be installed by anyone in no longer time than it takes to set up a stove. It will heat every room in your house in even the coldest weather with less fuel than it would take to do it in any other way.

Perfect Circulation Assured

One large register is located in the floor at a central point in the house. This register is divided into two parts—the warm air in the center and the cold air around the sides. Volumes of fresh, warm air are heated and discharged through the warm air portion of this register and rises straight to the ceiling of the room in which the register is located. The ceiling then acts as a deflector, sending the heated air through open stairways and doorways to adjoining rooms. These afford a perfect course for the travel of the heated air to the second floor and other parts of the house and when the air reaches the second floor the same process of heat travel and deflection is repeated.

Thus rising and spreading naturally the heated air penetrates to even the most remote parts of the house displacing the cooler air and forcing it downward until it is drawn back into the furnace through the cold air portion of the register. Here it is again heated and returned to repeat the same process of circulation. Warm air, therefore, is kept constantly circulating in a natural and easy manner making it possible to maintain a uniform temperature in every part of the house.

Ventilation Ceiling Register

For use in heating upstairs rooms. We advise using these ventilation registers in connection with our Pipeless furnaces where a quicker circulation is desired to the 2d floor rooms, especially bathroom. Comes complete with white enameled ceiling face and Black Japanned floor register; is adjustable connected with a spring and will fit any any size joist. Size of register 10 in. by 12 in.

The construction of this furnace is of that same sturdy type as embodied in our pipe furnaces shown on opposite page.

The fire pot is corrugated, thus assuring you that you will always be free from the danger of a cracked pot.

And then the ash pit door is large; likewise the ash pit itself, so that you will not burn out the grates in allowing the ashes to accumulate for a day or two. As the ash pit is made extra high it also does way with all back-breaking labor. It is air-tight.

Base Is Air Tight

The ash pit door is fitted directly onto the face of the ash pit thus insuring a perfect joint. You, therefore, will have an air-tight base allowing you absolute control of the fire.

Special attention has been given to the ease with which it is possible for you to shake the ashes. Our grates are of the popular triangle type and they work with very little friction. Our grates are so constructed that clinkers, no matter how large are easily broken up and removed.

All parts of the grate, including the grate rests and grate rest support, can be easily removed through the ash pit door.

We have equipped our furnaces with a large vapor pan which will at all times provide an ample supply of moisture in the warm air discharged from the furnace. Warm air without moisture is like the dry, stifling wind of the desert, whereas warm air laden with moisture has the effect of a tropical sea breeze.

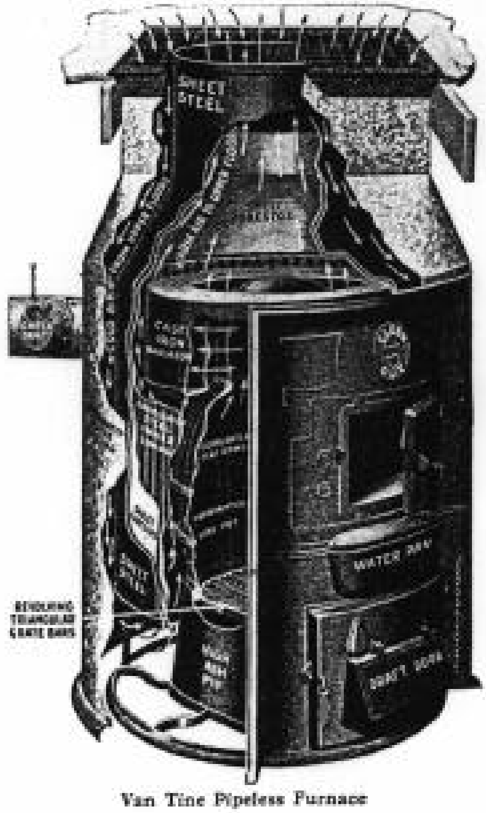
Radiators on the Van Tine one-register furnace are easily cleaned, thus allowing you to get the maximum heat from your coal at all times. The Gordon-Van Tine Company has sold many hundreds of these furnaces. They are working in all parts of the country and we will guarantee their satisfaction or refund your money.

Cold air returns are provided in some pipeless furnaces by cutting one or more openings in the bottom of the casing through which damp and often smelly cellar air is drawn. Where cellar conditions are not the best, such a system may prove a menace to the health of the entire family. The Van Tine draws air from the rooms of the house only.

In the last column on page 130, pipeless furnaces are priced for those Gordon-Van Tine homes in which our heating engineers may conscientiously recommend this form of heat.

These prices include furnace of a size to heat the home comfortably in any sort of weather, complete with register and 4 feet of smoke pipe and one ell.

Prices on Page 130, Fourth Column



Van Tine Pipeless Furnace

Figure 4. Ductless Furnace (source; Van Tine)

Guaranteed Prices-No Extras

Page 121

Plumbing Complete for Every Home

OUR Sanitary Engineers have carefully considered every Gordon-Van Tine home, and have laid out a piping and plumbing plan for it which is letter perfect. This service alone would cost at least $100.00 if you bought it for your house alone, but Gordon-Van Tine's great volume enables us to give this service with no expense to you. It is included with the order, like our architectural service.

Plumbing Planned by Experts

Plumbing is so important to health that you cannot afford to take chances. No matter how well intentioned a man might be, if he were not a doctor you would not let him prescribe for your children if they were sick, and no matter how well intentioned a plumbing mechanic may be, you should not let him lay out your plumbing plans. Get trained, professional advice and service every time.

Standard weight galvanized steel piping is used throughout for water supply pipes. Sizes are carefully calculated to secure an even water pressure throughout the house at all times. Piping is so designed as to drain the whole system from one point, making it easy in case you wish to close the house up in winter at any time.

Shut-off is provided for entire system. Hot water piping arranged so that even pressure and quick delivery of hot water are obtained.

Complete Directions for Installing

Complete plans and instructions furnished which will enable you to install the system without difficulty. Bills of materials are guaranteed complete. If there are any shortages or extras, we guarantee to furnish them or pay for them providing our plans and instructions are carefully followed.

A wide range of fixtures are shown on the following pages. Make your choice from the designs shown and see page 129 for prices complete for any house in our Plan Book for which plumbing is furnished. For customers living on the farm, we show complete pressure systems in a separate circular. (See Note at bottom of page.) These used in connection with our plumbing installation make it possible to buy direct from us a complete system to meet any requirements. Systems are illustrated and prices shown so that you can easily decide on combination you desire.

Illustration shows typical installation of Washington Set—showing also Pressure System No. 6A720 and Septic Tanks. Pressure System and Septic Tanks are not included except where desired and are priced separately.

Sewage Disposal Systems

The cut also shows the Gordon-Van Tine Natural Way Sewage Disposal System. The most efficient system known to science today. Made of reinforced concrete, practical, saves you money and time and absolutely protects your family from sickness.

Chemical action, first in one tank, then in the other, reduces all sewage waste into a harmless odorless liquid, which is discharged from the second tank, and is easily disposed of.

GORDON Natural Way Sewage Disposal consists of two concrete tanks, made of best grade Portland cement. Tanks are cylindrical in shape, being molded in one piece and are thoroughly reinforced with special steel reinforcing. Covers are cast separate, also being reinforced. There are no metal fittings or parts of any kind, in our tanks, thus eliminating corrosive and electrolytic action. This feature is of great importance.

All tanks are thoroughly waterproofed inside and out, and if not used beyond rated capacity, need be cleaned only once in four or five years!

Two Tank Sewage Disposal System

Catalog Number	Capacity Persons	1st Tank	2nd Tank	Shipping Weight
6A9453	5	24 x 32	24 x 36	1550
6A9454	8	30 x 32	24 x 36	1850

If vitrified tile fittings are wanted with tanks add $5.00.

Prices on All Sizes on Page 129

Western shipments made from Davenport. Eastern shipments from North Carolina.

Pressure Water Supply Systems (cylindrical tank in basement in above illustration) are described, illustrated and priced very low in a separate circular. These are used where there is no city pressure and may be operated by hand, gas engine or electricity. *If interested send for this Free Circular.*

Figure 5. Two Tank Cesspool (source Van Tine)

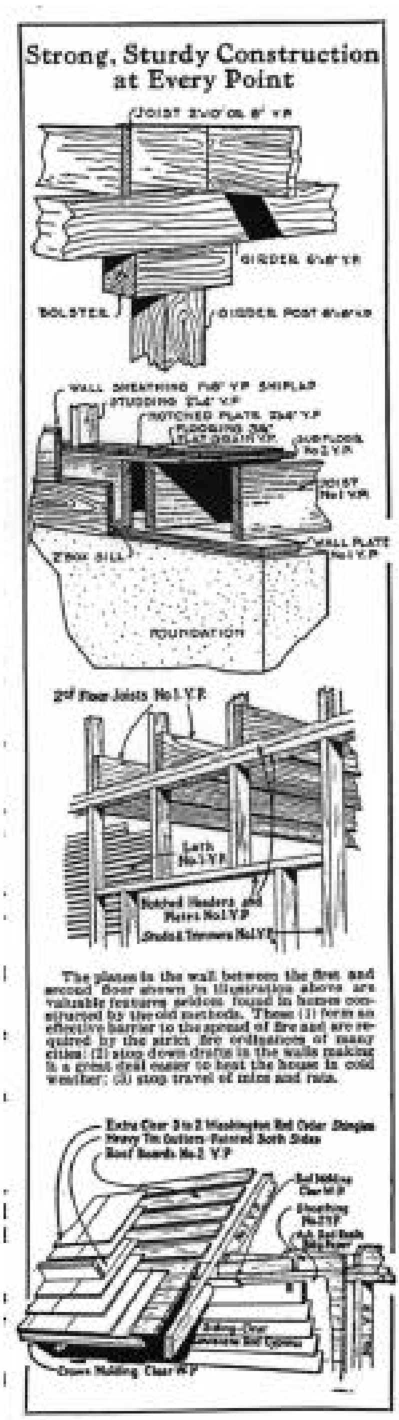


Figure 6. Modified Platform frame with notched plates (source; Van Tine)

[1] Cavanagh, Ted, "Balloon Houses; The Original Aspects of Conventional Wood-Frame Construction Re-Examined" Journal of Architectural Education, 1997.
Cavanagh's refutation of the attribution of the balloon frame to Snow, or Chicago is compelling. However the primary arguement's dependence on the writing of Latrobe seem to fall victim to the same weakness the author attributes to Sprague. That being the lack of documentary evidence of a citation by Latrobe of materials or manner of construction of the "Frame and Clapboard" structures noted in Chicago, Independence, and Little Rock. The author's reluctance to accept the possibility that Latrobe could have been speaking

precisely and describing timber or box framing and not light wood framing casts him into a similar light of speculation with which he discards Sprague.

A review of "The Modern Builders Guide" published in 1833, close to the time of the alleged introduction of the "Balloon frame" shows that "balloon," was not in accepted use in the building profession, nor is there any description of light wood constructions. "Scantling," a term used by Sprague to describe the construction method used by Snow to build the 1832 warehouse at the mouth of the Chicago river, is defined in the guide as "The transverse dimension of a piece of timber; sometimes also the small timbers in roofing and flooring are called *scantlings*." The "Carpenter's Company 1786 rule book" however does show a *"Framed Wall with Studding" with an accompanying notation "This two story end frame with two entrances may well have been for a meeting house with its 30' gable facing the street. Here the frame is "full studded" and ready for nailing weather boarding to the outside and lathing and plastering within."* So Latrobe may have been looking at a timber frame infilled with studding and covered with clapboards when he was writing about "frame and clapboard houses."

[2] Rykwert, Joseph On Adams House in Paradise MIT Press, Cambridge, MA 1981
[3] Elliott, Cecil, Technics in Architecture MIT Press, Cambridge, MA 1992
[4] Elliott, Cecil, Technics in Architecture MIT Press, Cambridge, MA 1992
[5] Woodward, George and Thompson, Edward Victorian Housebuilders Guide, Dover Press, Mineola, NY, 1869
[6] Stickley, Gustav, The Craftsman, Dover Press, Mineola, NY 1982
[7] Peterson, Fred, Homes in the Heartland, University of Kansas Press, Lawrence KS, 1992
[8] Bennett, Ray, H. Lumber Co., Ray Bennett precut homes, Dover Press, Mineola, NY 1993 (reprint of 1920 catalog published in North Tonawanda, NY.)
[9] Tine, Gordon-Van Company, Gordon-Van Tine precut homes catalog, Anetheum of Philadelphia, Dover Press, Mineola, NY 1992. (reprint of 1923 catalog published in Davenport, IA.)
[10] Sargent, John, Frank Lloyd Wrights Usonian Homes Whitney Library of Designs, New York, NY, 1984
[11] Elliott, Cecil, Technics in Architecture MIT Press, Cambridge, MA 1992

Timber Frame is industry standard

1795 — Jacob Perkins patents the nail making machine

1800 — 16 major cities have central water systems

1811 — New Madrid Earthquake

1833 — Balloon frame emerges from the Midwest

-wood frame
-cedar roof
-wood siding
-outdoor toilet
-well / cistern water
-fireplace
-area rugs over hardwood floors

1869

furnace induced humidity reduction cited as health concern by Catherine Beecher

Add:
-gaslight piping
-attached outdoor toilets
-cesspool
-lead waste piping
-lead water piping
-coal fired hot water boiler
-zinc conduit for doorbell
-plaster & wallpaper

Great Chicago Fire 1871

property losses due to gaslight fires / leaks

lead water systems common

1880

Add:
-electric lighting circuits
-telephone circuits
-“iced” boxes common
-kerosene fired water heaters
-attached garages

Replace
-lead waste piping with cast iron
-fireplace with hot air ductless furnace
-cedar shingles with rolled asphalt roofing

Remove
-fireplace as primary heat source

1907 — San Fransisco Earthquake

1919 Platform frame begins supplanting balloon

Add:
-tarred paper under siding
-backplastered stud cavities for insulation
-two full baths

Replace:
-cesspool with two tank septic
-ductless hot air furnace with ducted hot air furnace
-lead water pipe with galvanized iron water pipe

lead water systems out

1922

Add:
-extra building paper around door & window opening as flashing
-asphalt roof shingles
-lead based paint

Replace
-plaster and wall paper with plasterboard

now appearing:
-radiant hot water heating systems in floor slabs

1933 — the light wood frame turns 100!

1948

Replace:
-backplastering with fiberglass or mineral fiber insulation
-Asbestos reinforced:
  pipe insulation
  plaster
  vinyl tile
  cement siding
  cement shingles
-Cistern/well with city water

now appearing:
-plywood
-home air conditioning

1960's

- lead solder for copper pipe
- "white lung" in asbestos workers

Add:
- Antennae systems
- Smoke detectors
- Basement dampproofing

Replace:
- 1x6 sheathing with plywood
- area rugs with wall to wall carpet.
- galvanized iron water pipe with copper pipe
- oil paint with latex paint

Now appearing:
- Fire retardent treated plywood
- Salt treated pine
- Foam plastic insulation
- Construction adhesives
- Power nailers / staplers
- Aluminum siding
- Home humidifiers

1970's

- Lead banned from paint, removal mitigation processes implemented
- New industries emerge to remove:
  - Asbestos reinforced:
    - pipe insulation
    - plaster
    - vinyl tile
    - cement siding
    - cement shingles
- tighter envelopes & increased VOC's lead to indoor air quality questions
- wood siding failures over foil faced sheathings
- ice dams at eaves become more common with thicker insulation plugging eave vents
- Radon testing / mitigation becomes common

Add:
- -active solar panels, tanks
- -vapor barriers in residential walls/roofs/slabs
- -more insulation for increased "R" values
- -glued down carpet
- -foil faced insulated wall sheathing
- -particle board floor underlayment
- -eave vent chutes

Replace:
- -solid hardwood millwork with veneered particle board.
- -solid sawn roof rafters with plate trusses
- -galvanized ductwork with foil faced fiberglass ductboard

now appearing:
- -low infiltration envelopes
- -home air conditioning
- -insulating glass
- - natural gas utilities for:
  - clothes dryers
  - ovens / ranges
  - furnaces
- -ureaformaldehyde foamed in place insulation
- -duct tape
- fiberglass roof shingles
- home HEPA air filters

1980's

- premature roof shingle failures due to overheating, plugged eave vents

Add:
- -home irrigation systems
- -home security systems
- -home theater systems
- -housewrap wind barriers
- -foundation drain board

Replace:
- -wood door / window frames with vinyl clad frames
- -wood siding with vinyl siding
- -plywood sheathing with OSB sheathing
- -cast iron waste piping with PVC
- -antennae systems with cable tv system.

Now appearing:
- Hardboard siding
- Polybutylene water piping
- HCFC based foam plastic insulation
- -heat pumps
- -CCA treated pine
- -90+% efficient gas furnaces
- -air to air heat exchangers
- -foil faced flexible ductwork
- -low "e" coatings for insulating glass

1990's

- Mercury free latex paint common
- Hurricane Andrew $24billion in damage
- lead - free solder required for all plumbing uses
- U.S. national toxicology program adds fiberglass to 7th annual report on carcinogens
- some fire departments question performance of plate trusses and I-joists in floors.
- EIFS contributes to accelerated wood frame deterioration in the southeastern U.S.
- OSB siding / trim failure results in class action suit / settlement
- Extended drought hits eastern U.S.
- CISH formed 1998

Add:
- -carbon dioxide detectors
- -vapor barriers in residential walls/roofs/slabs
- -foil faced insulated wall sheathing
- -particle board floor underlayment
- -eave vent chutes
- -ice guard waterproofing at overhangs

Replace:
- -insulated wall sheating with OSB for vinyl siding
- -solid sawn floor joists with plate trusses or I- joists
- -glued down carpet with mechanically fastened
- -wood siding with EIFS

now appearing:
- -lower formaldehyde particle board
- -3 stage furnace / heat pump fans for continuous circulation/filtration/humidification
- -OSB siding / trim
- -home fire sprinkler systems